

**WHAT IS CLAIMED IS:**

1. A method to perform low-density parity-check code encoding of user data  $u$  of length  $N_u$ , by inserting parity data  $p$  of length  $N_p$  into output data  $c$  of length  $N$  in accordance with a parity matrix  $H$  such that  $H \bullet c = 0$ , comprising the steps of:

- 5 (a) receiving the user data of block length  $N_u$ ;
- (b) decomposing  $H \bullet c$  into a first component  $H_u \bullet u$  corresponding to the user data and a second component  $H_p \bullet p$  corresponding to the parity data such that  $H_u \bullet u + H_p \bullet p = 0$ ;
- (c) calculating a vector  $\underline{u} = H_u \bullet u$ ; and
- 10 (d) calculating  $p = H_u^{-1} \bullet \underline{u}$ .

2. The method of Claim 1, wherein  $H_u$  comprises a  $N_p \times N_u$  matrix and  $H_p$  comprises a  $N_p \times N_p$  matrix.

3. The method of Claim 1, further comprising the step of:

- (e) receiving address information,
- 15 wherein step (c) is performed in accordance with step(e).

4. The method of Claim 1, wherein step (c) comprises the step of:

- (f) updating elements of  $\underline{u}$  as follows:

$$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}.$$

5. The method of Claim 1, wherein step (d) comprises the step of:

- 20 (g) reducing a row weight of  $H_u^{-1}$  by representing  $H_u^{-1}$  as  $M1 * M2$ .

6. The method of Claim 1, wherein step (d) comprises the step of:

(g) reducing a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $\prod_{i=1}^s M_i$ .

7. The method of Claim 1, wherein step (c) is performed prior to step (d).

8. A low-density parity-check code encoder to encode user data  $u$  of length  $N_u$ , by inserting parity data  $p$  of length  $N_p$  into output data  $c$  of length  $N$  in accordance with a parity matrix  $H$  such that  $\mathbf{H} \bullet \mathbf{c} = 0$ , comprising:

an input to input the user data of block length  $N_u$ ;

an  $H$   $c$  decomposer to decompose  $\mathbf{H} \bullet \mathbf{c}$  into a first component  $\mathbf{H}_u \bullet \mathbf{u}$  corresponding to the user data and a second component  $\mathbf{H}_p \bullet \mathbf{p}$  corresponding to the parity data such that  $\mathbf{H}_u \bullet \mathbf{u} + \mathbf{H}_p \bullet \mathbf{p} = 0$ ;

a  $\underline{u}$  calculator to calculate a vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$ ; and

a  $p = \underline{P} \underline{u}$  calculator to calculate  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

9. The encoder of Claim 8, wherein  $\mathbf{H}_u$  comprises a  $N_p \times N_u$  matrix and  $\mathbf{H}_p$  comprises a  $N_p \times N_p$  matrix.

10. The encoder of Claim 8, further comprising:

a second input to input address information,

wherein said  $\underline{u}$  calculator calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  in accordance with said second input.

11. The encoder of Claim 8, wherein said  $\underline{u}$  calculator updates elements of  $\underline{u}$  as follows:

$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}$ .

12. The encoder of Claim 8, wherein said  $p = \underline{P} \underline{u}$  calculator reduces a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $M1 * M2$ .

13. The encoder of Claim 8, wherein said  $p=\underline{P} \underline{u}$  calculator reduces a row weight of

$\mathbf{H}_u^{-1}$  representing  $\mathbf{H}_u^{-1}$  as  $\prod_{i=1}^s M_i$ .

14. The encoder of Claim 8, wherein said  $\underline{u}$  calculator calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  prior to said  $p=\underline{P} \underline{u}$  calculator calculating  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

5 15. A computer program to perform low-density parity-check code encoding of user data  $u$  of length  $N_u$ , by inserting parity data  $p$  of length  $N_p$  into output data  $c$  of length  $N$  in accordance with a parity matrix  $H$  such that  $\mathbf{H} \bullet \mathbf{c} = 0$ , comprising the steps of:

(a) receiving the user data of block length  $N_u$ ;

10 (b) decomposing  $\mathbf{H} \bullet \mathbf{c}$  into a first component  $\mathbf{H}_u \bullet \mathbf{u}$  corresponding to the user data and a second component  $\mathbf{H}_p \bullet \mathbf{p}$  corresponding to the parity data such that  $\mathbf{H}_u \bullet \mathbf{u} + \mathbf{H}_p \bullet \mathbf{p} = 0$ ;

(c) calculating a vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$ ; and

(d) calculating  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

15 16. The computer program of Claim 15, wherein  $\mathbf{H}_u$  comprises a  $N_p \times N_u$  matrix and  $\mathbf{H}_p$  comprises a  $N_p \times N_p$  matrix.

17. The computer program of Claim 15, further comprising the step of:

(e) receiving address information,

wherein step (c) is performed in accordance with step(e).

18. The computer program of Claim 15, wherein step (c) comprises the step of:

20 (g) updating elements of  $\underline{u}$  as follows:

$$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}.$$

19. The computer program of Claim 15, wherein step (d) comprises the step of:

(g) reducing a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $M1 * M2$ .

20. The computer program of Claim 15, wherein step (d) comprises the step of:

(g) reducing a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $\prod_{i=1}^s M_i$ .

21. The computer program of Claim 15, wherein step (c) is performed prior to step  
5 (d).

22. A data transmission system for transmitting user data to and receiving data from a communication channel, comprising:

a low-density parity-check code encoder to encode user data  $u$  of length  $N_u$ , by inserting parity data  $p$  of length  $N_p$  into output data  $c$  of length  $N$  in accordance with a parity matrix  $H$  such that  $\mathbf{H} \bullet \mathbf{c} = 0$ , comprising:  
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an input to input the user data of block length  $N_u$ ;

an  $H$  c decomposer to decompose  $\mathbf{H} \bullet \mathbf{c}$  into a first component  $\mathbf{H}_u \bullet \mathbf{u}$  corresponding to the user data and a second component  $\mathbf{H}_p \bullet \mathbf{p}$  corresponding to the parity data such that  $\mathbf{H}_u \bullet \mathbf{u} + \mathbf{H}_p \bullet \mathbf{p} = 0$ ;

a  $\underline{u}$  calculator to calculate a vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$ ; and  
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a  $\underline{p} = \underline{P} \underline{u}$  calculator to calculate  $\underline{p} = \mathbf{H}_u^{-1} \bullet \underline{u}$ ;

a transmitter to transmit an output of said low-density parity-check code encoder to the communication channel;

a soft channel decoder to decode data from the communication channel; and

20 a soft low-density parity-check code decoder to decode data decoded by said soft channel decoder.

23. The system of Claim 22, wherein  $\mathbf{H}_u$  comprises a  $N_p \times N_u$  matrix and  $\mathbf{H}_p$  comprises a  $N_p \times N_p$  matrix.

24. The system of Claim 22, further comprising:

an address generator to generate address information in accordance with the user data;

second input means for inputting address information,

5 a second input to input address information,

wherein said  $\underline{u}$  calculator calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  in accordance with said second input.

25. The system of Claim 22, wherein said  $\underline{u}$  calculator updates elements of  $\underline{u}$  as follows:

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$$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}.$$

26. The system of Claim 22, wherein said  $p = \underline{P} \underline{u}$  calculator reduces a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $M1 * M2$ .

27. The system of Claim 22, wherein said  $p = \underline{P} \underline{u}$  calculator reduces a row weight of  $\mathbf{H}_u^{-1}$  representing  $\mathbf{H}_u^{-1}$  as  $\prod_{i=1}^s M_i$ .

15 28. The system of Claim 22, wherein said  $\underline{u}$  calculator calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  prior to said  $p = \underline{P} \underline{u}$  calculator calculating  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

29. A low-density parity-check code encoder to encode user data  $\mathbf{u}$  of length  $N_u$ , by inserting parity data  $\mathbf{p}$  of length  $N_p$  into output data  $\mathbf{c}$  of length  $N$  in accordance with a parity matrix  $\mathbf{H}$  such that  $\mathbf{H} \bullet \mathbf{c} = 0$ , comprising:

20 input means for inputting the user data of block length  $N_u$ ;

$\mathbf{H} \mathbf{c}$  decomposer means for decomposing  $\mathbf{H} \bullet \mathbf{c}$  into a first component  $\mathbf{H}_u \bullet \mathbf{u}$  corresponding to the user data and a second component  $\mathbf{H}_p \bullet \mathbf{p}$  corresponding to the parity data such that  $\mathbf{H}_u \bullet \mathbf{u} + \mathbf{H}_p \bullet \mathbf{p} = 0$ ;

$\underline{u}$  calculating means for calculating a vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$ ; and

$p = \underline{P} \underline{u}$  calculating means for calculating  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

30. The encoder of Claim 29, wherein  $\mathbf{H}_u$  comprises a  $N_p \times N_u$  matrix and  $\mathbf{H}_p$  comprises a  $N_p \times N_p$  matrix.

5 31. The encoder of Claim 29, further comprising:

second input means for inputting address information,

wherein said  $\underline{u}$  calculating means calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  in accordance with said second input means.

10 32. The encoder of Claim 29, wherein said  $\underline{u}$  calculating means updates elements of  $\underline{u}$  as follows:

$$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}.$$

33. The encoder of Claim 29, wherein said  $p = \underline{P} \underline{u}$  calculating means reduces a row weight of  $\mathbf{H}_u^{-1}$  by representing  $\mathbf{H}_u^{-1}$  as  $M1 * M2$ .

15 34. The encoder of Claim 29, wherein said  $p = \underline{P} \underline{u}$  calculating means reduces a row weight of  $\mathbf{H}_u^{-1}$  representing  $\mathbf{H}_u^{-1}$  as  $\prod_{i=1}^s M_i$ .

35. The encoder of Claim 29, wherein said  $\underline{u}$  calculating means calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  prior to said  $p = \underline{P} \underline{u}$  calculating means calculating  $p = \mathbf{H}_u^{-1} \bullet \underline{u}$ .

36. A data transmission system for transmitting user data to and receiving data from a communication channel, comprising:

20 low-density parity-check code encoding means to encode user data  $u$  of length  $N_u$ , by inserting parity data  $p$  of length  $N_p$  into output data  $c$  of length  $N$  in accordance with a parity matrix  $H$  such that  $H \bullet c = 0$ , comprising:

input means for inputting the user data of block length  $N_u$ ;

$H_c$  decomposer means for decomposing  $H \cdot c$  into a first component  $H_u \cdot u$  corresponding to the user data and a second component  $H_p \cdot p$  corresponding to the parity data such that  $H_u \cdot u + H_p \cdot p = 0$ ;

5  $\underline{u}$  calculating means for calculating a vector  $\underline{u} = H_u \cdot u$ ; and

$p = P \underline{u}$  calculating means for calculating  $p = H_u^{-1} \cdot \underline{u}$ ;

transmitting means for transmitting an output of said low-density parity-check code encoding means to the communication channel;

soft channel decoding means for decoding data from the communication  
10 channel; and

soft low-density parity-check code decoding means for decoding data decoded by said soft channel decoding means.

37. The system of Claim 36,, wherein  $H_u$  comprises a  $N_p \times N_u$  matrix and  $H_p$  comprises a  $N_p \times N_p$  matrix.

15 38. The system of Claim 36,, further comprising:

address generator means for generating address information in accordance with the user data;

second input means for inputting the address information,

20 wherein said  $\underline{u}$  calculating means calculates the vector  $\underline{u} = H_u \cdot u$  in accordance with said second input means.

39. The system of Claim 36,, wherein said  $\underline{u}$  calculating means updates elements of  $\underline{u}$  as follows:

$$\underline{u}(i) = \underline{u}(i) \oplus \text{bit}.$$

41. The system of Claim 36., wherein said  $p=\underline{p}$   $u$  calculating means reduces a row weight of  $\mathbf{H}_{\mathbf{u}^{-1}}$  representing  $\mathbf{H}_{\mathbf{u}^{-1}}$  as  $\prod_{i=1}^s M_i$ .

5 42. The system of Claim 36,, wherein said  $\underline{u}$  calculating means calculates the vector  $\underline{u} = \mathbf{H}_u \bullet \mathbf{u}$  prior to said  $\mathbf{p} = \mathbf{P} \underline{u}$  calculating means calculating  $\mathbf{p} = \mathbf{H}_u^{-1} \bullet \underline{u}$ .